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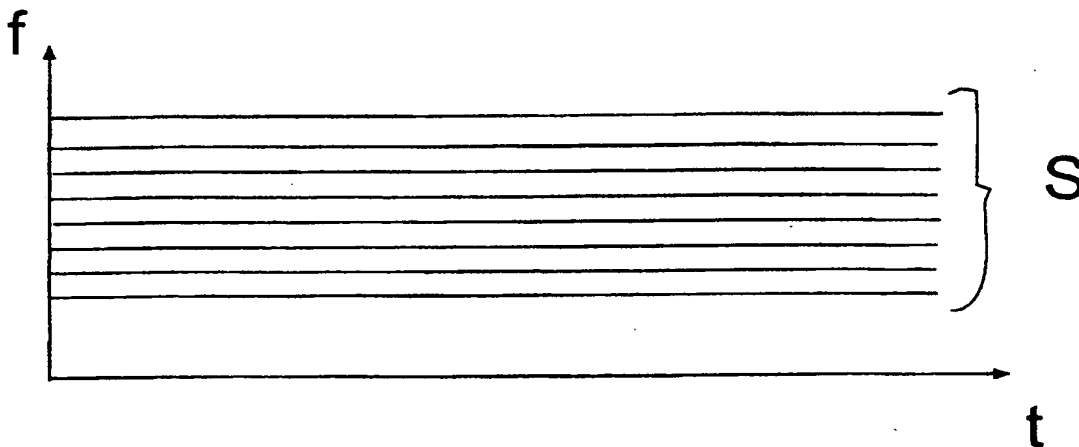
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(54) Title: METHOD AND DEVICE AT TELECOMMUNICATION SYSTEM



(57) Abstract: The present invention relates to a method and device at telecommunication systems for allocation of resource range to user from the given range capacity of the system. For the purpose an optimization problem is utilized that can be solved by Branch and Bound methods. Maximum is searched for, for the sum of all to the users allocated resources with an allocated weighting indicating the order of preference between the users. The indicated problem is solved provided that each user is allocated maximally one resource, that each user is allocated at least the resource that is necessary, and that the allocated resource does not exceed a defined highest resource. Further that the sum of all allocated resources does not exceed the total resources of the system. Calculation and allocation of the resource allocation is performed in one in the system integrated calculation and allocation device.

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## TITLE OF THE INVENTION

Method and device at telecommunication system

Technical field

5 The present invention relates to telecommunication networks, especially digital telecommunication networks, where coded transmission is applied. The invention is specifically aimed at allocation of resources in the CDMA-  
10 available frequency range on the air.

Technical problem

In the social state of today the need to transmit and receive large amounts of information is increasing. For  
15 this reason there is a desire to utilize the available frequency range efficiently with regard to the resources of the system and the needs of the users at each moment. The implication of this is that the system in different situations has to take into consideration various needs of  
20 established and wanted communications. In CDMA (Code Division Multiple Access)-systems this possibility is given, but efficient methods for allocation of and sorting of information are lacking. The present invention aims at presenting a solution to above mentioned problem. UMTS  
25 (Universal Mobile Telecommunication System) is the European term for the third generation of mobile systems which is planned to be in operation at the beginning of twenty-first century. The system has three defined modes which all have that in common that they are using CDMA in some form.

30

In order to discern between different users in CDMA-based systems, i.e. obtain orthogonality between them, different forms of codes are used, hence the name "Code Division Multiple Access". In UMTS WCDMA two kinds of codes are  
35 used, spreading codes and scrambling codes. The spreading code spreads information that shall be transmitted at a

chip rate of 3,84 Mchip/s. The length of the spreading code varies from 1-512 bit depending on present data speed. The scrambling codes on the other hand do not change the number of bits that shall be transmitted but only change the value of them according to a well defined schedule.

In downlink it is the spreading code that guarantees the orthogonality between different users in the same cell. In order to maintain the orthogonality irrespective of which data speed that is used at the transmission, so called Orthogonal Variable Spreading Factor, OVSF-codes, are used. The OVSF-codes are easiest illustrated by a code tree, see Figure 4.

Each level in the code tree defines a channel code with length SF. All codes in the tree cannot be used at the same time within a cell. A code can be used in a cell if, and only if, no other code along the path from the specific code to the root of the code tree or in the sub-tree under the specific code is used in the cell.

It is easy to realize that a totally arbitrary allocation of codes results in a very inefficient use of the available codes. For this reason it is of great interest to in some way make the use of codes more efficient. The present invention provides an optimal allocation of codes based on criteria defined by the operator.

#### Prior art

Within mobile communication the technology has developed since the first systems appeared. In the first systems, according to Figure 1, a range S, was allocated within a given frequency spectrum. In order to satisfy the communication needs, the range, S, was divided into a number of channels, k, which were allocated to the users. In these first systems, the channels, k, were of the same size, and the transmission capacity were the same for all users irrespective of need. Systems with this construction

only allow one transmission (communication) at the same time, corresponding to the number of channels that are available within an area.

5 Concurrently with the growth of the mobile communication, the need for a larger number of transmissions has increased. This has been met with the introduction of digitized communication, which is shown in Figure 2. In this case the range, S, is still divided into a number of  
10 channels, but the information is transmitted in time slots, T1, T2 etc. This technology is called TDMA, which considerably increases the transmission capacity in the mobile radio networks. The technology consequently makes possible that more transmissions share one and the same  
15 frequency.

In common for each above mentioned technology is that they have been created for transmission of in the first place speech and at that have been given fixed frames for the use  
20 of them.

A development of the TDMA-system is the CDMA-system where the range, S, is not divided into a number of channels but the whole available range is utilized, at which defined  
25 codes are utilized to discern between the pieces of information that shall be identified. The technology for identification of and sorting of information is in itself since before known to the expert in the field.

### 30 The solution

The present invention relates to a method at telecommunication systems utilizing CDMA (Code Division Multiplex Access)-technology at exchange of information between users. Resources are allocated to users,  
35 corresponding to at least a lowest requested capacity. A weighting, related to an order of priority between the

users, is further allocated each moment to the users. Based on available information, the capacity is allocated to the users according to a maximal allocation with regard to that the total capacity of the system is not exceeded.

5

The optimization problem that shall be solved is that maximum for the sum of all to the users allocated resources, with regard to the mentioned weighting, appoints an allocation of resources between the users. Further,  
10 allocated resources at each level shall correspond to one to user necessary lowest resource, and that the sum of all to the users allocated resources is covered by the total capacity of the system, and that each user is allocated one code at most. The mentioned weighting is further expressed  
15 by integers, which results in that the optimization problem is possible to solve by Branch and Bound methods. The solution makes possible that in the system available resources are allocated and reallocated between the users depending on the solution of the optimization problem. At  
20 allocation of the resources is aimed at that free resources are created, which constitute reserves for future needs.

The invention further relates to a device at telecommunication systems utilizing CDMA, Code Division  
25 Multiple Access, technology for exchange of information between users. Further, resources shall be allocated to the users. For the purpose the system is arranged to allocate to the users resources corresponding to at least a lowest indicated capacity. The system further allocates to the  
30 users a weighting according to the users' at each time allocated order of priority. The system further includes a calculation and allocation unit which at each time calculates an optimal allocation of available resources, according to which resources are allocated or reallocated  
35 between the users within the total capacity of the system. The calculation and reallocation device is arranged to

calculate maximum for the sum of all to the user's allocated resources in relation to indicated weightings. The solution of the optimization problem at that indicates how the resources shall be allocated between the users. The system  
5 further provides information of the calculation and allocation device indicating largest and smallest resources that respective user needs at each moment. The optimization problem is solved with regard to that the users are allocated at least the lowest resource that is needed and  
10 that the resources of the system are not exceeded. Consideration is further taken to that the optimization problem is solved with regard to that the users are allocated maximally one code.

#### 15 Advantages

The invention makes possible that resources, codes in the CDMA-case, in a frequency spectrum is given an optimal allocation depending on the users' need at each time. This means on the one hand that the users are only allocated the  
20 channel range that is needed each time, on the other that the resources that exist are allocated in best possible way in order to create range for future needs.

Further, the invention presents a definition of the  
25 existing optimization problem, at which the problem can be set in a form which can be solved by Branch and Bound methods. The consequence of this is that mathematical methods suitable to be solved by means of computer programs can be introduced and connected with the allocation of  
30 channels to the users. Further advantages are that a priority between the users is introduced and this is allowed to vary depending on if the users have been allocated resources or not, and depending on the time of the day, the number of users each time etc.

Description of figures

Figure 1 shows channel allocation in an analog radio system.

Figure 2 shows channel allocation in a packet oriented  
5 radio system.

Figure 3 shows the utilization of spectrum in a system according to the invention.

Figure 4 shows the tree structure of channels according to the invention.

10

Preferred embodiment

In the following, the invention is described on basis of the figures and the terms in them.

15 The present invention relates to a method and device at telecommunication systems for allocation of resource range to users from the given capacity range of the system. For the purpose an optimization problem is utilized which can be solved by Branch and Bound methods. Maximum is searched  
20 for the sum of all to the users allocated resources with an allocated weighting indicating the order of precedence between the users. The indicated problem is solved provided that all users are allocated maximally one resource; that each user is allocated at least the resource that is  
25 necessary, and that the allocated resource does not exceed a defined highest resource. Further, that the sum of all allocated resources does not exceed the total resources of the system. Calculations and allocation of the resource allocation is performed in one in the system integrated  
30 calculation and allocation device.

Allocation of resources to users shall be performed according to a pattern which gives optimal utilization of available resources. Allocation is made in a code tree,  
35 which is shown in Figure 4, where consideration shall be taken to which resources that already have been allocated

to users. In order to find out if a resource has been allocated to a user, a variable  $x$  with index  $i$  is defined for the user, and  $j$  for the resource. Said variable  $x$  is consequently given the value 1, if the resource is  
5 allocated to the user, or 0 when no resource is given to said user.

The number of resources at level  $j$  for users  $i$  is described by a variable  $y$  with index  $i$  indicating the user, and  $j$   
10 indicating the level in question. The number of resources  $y$  at level  $j$  is defined as 2 raised to  $j$ . The value  $j$  is set to  $512/SF$ , where  $SF$  is the spreading factor. That 512 is used in this connection is due to existing practice. Utilizing other numbers are as such no obstacle to the  
15 invention which allows any number within specified definitions. Further are defined a highest and a lowest value which the variable is allowed to take. The lowest value at this indicates the lowest resource that can be allocated to a user,  $x$ , to make it possible to him/her to  
20 execute the wanted communication. The maximal resource defines the largest resource that a user needs. The sum of all allocated resources which are utilized by the users shall amount to, or be below, the available capacity. Said total resource consequently shall be allocated between  
25 users the capacity needs of whom on the one hand are different, and on the other can vary in time. Further, the users are given a weighting,  $\alpha$ , which indicates how important it is that said user is allocated a resource in relation to other users. The weighting is allowed to vary  
30 depending on whether the user is already allocated a resource or not. Further, the weighting indicates whether a user has a higher priority than another user. By these definitions consequently a possibility is given to decide orders of priority between users who have been allocated  
35 resources and those who shall be allocated resources, in the existing system. The indicated weighting as such is



allowed to take any value, but in order to create an optimization problem for  $x$ , it is of advantage to utilize integers. This results in an optimization problem where maximum is searched for, for the sum of all allocated resources with belonging weighting, provided that available resources are not exceeded, and that the user is given the lowest resource that is required, and that the sum of all to users allocated resources do not exceed the maximal capacity of the system, and that each user is only allocated one code which defines a resource being within an interval defined by the user's highest and lowest need. In the problem consequently is included to decide whether the users shall be allocated resources or not, and in the cases allocations are made, the size of the resource. With a set up as has been described above, a formulation has been created which is classic within the optimization theory, and which for instance is solved by means of Branch & Bound-methods, which can be found in manuals for optimization theory.

20

The following problems shall be solved

$$\max \sum_i \sum_j a_{i,j} x_{i,j} y_{i,j} : \text{given} : m_i \leq M, \forall i$$

$$m_i \leq y_{i,j} \leq M,$$

$\alpha$  is a weight which is set by the operator for each user.

$$\text{given, } \sum_i \sum_j x_{i,j} y_{i,j} \leq N$$

25 where  $N$  is the capacity in the base station, and

$$\sum_j x_{i,j} \leq 1$$

further applies that

$$x_{i,j}$$

= binary variable which indicates if user  $i$  is allocated on resource  $j$

$$x_{i,j} \in \{0,1\}, \sum_j x_{i,j} \leq 1$$

$$y_{i,j} = 2^j$$

the number of resources for user  $i$  at level  $j$ , where  $j=512/SF$  where  $SF$  is the spreading factor

5

$$m_i \leq y_{i,j} \leq M_i$$

where  $m(i)$  represents the lowest value of  $y(i,j)$  and  $M(i)$  the maximal value of  $y(i,j)$

10 Orthogonality for the channels is further a demand in the solving of problem above.

In the formulation of the problem above, the weights,  $\alpha_{i,j}$  have been selected as integers, which results in that the code allocation problem is set to a form which is known and  
 15 where efficient methods for solving exist. The final value of the goal function, in optimum, is in this connection of secondary importance because only the vector  $x$  that reaches optimum is of interest. The absolute values of  $\alpha_{i,j}$  consequently are not of interest, but only the relation  
 20 between them. Because the weights can be set to arbitrary values, and especially integer values, a relative weighting between the terms can be achieved. By dividing the goal function by an integer is realized that a weighting can be  
 25 achieved between the different components which is arbitrary close to a weighting where real values of the weights are allowed.

Because the problem is not static, but is changed by time, is required that the system continuously solves the above  
 30 described optimization system. For this purpose the system

is given a module which has the task to calculate the optimization problem and to, based on its solution, allocate the resources between the users. The information required to find out the different needs of the users at  
5 each point of time are retrieved from respective user and from the operator/operators who are responsible for the users and the capacities that are needed.

At each moment consequently there is a collecting of  
10 information from users and operators regarding the wishes of the users, the criteria of the operators for the users in the calculating and resource allocating device. After that, the solution of the optimization problem is calculated, which solution not necessarily has to be solved  
15 exactly, but only has to be solved regarding the order of magnitude. At the solution of the optimization problem, however, is needed that the vector  $x$  shall be obtained as integer with elements the values of which are 0 or 1. The calculation module after that decides how the resources are  
20 allocated between the users and if the resource allocation shall be changed for one or more of the users with the intention to optimize the utilization of in the system available maximal resources and, as far as possible, create reserve range for future needs from the users.

25 The invention is not limited to in the above described example of embodiment, or to the following patent claims, but can be subject to modifications within the frame of the idea of the invention.

## PATENT CLAIMS

1. Method at telecommunication system, utilizing Code  
Division Multiple Access, CDMA, technology for  
5 transmission of information between users,  
c h a r a c t e r i z e d in that the users are  
allocated resources corresponding to at least a lowest  
capacity that the user requests, that the users at each  
moment are allocated a weighting indicating the users'  
10 priority between them, that the resources at each moment  
are allocated according to an optimal allocation with  
taking into account that the total resources of the  
system is not exceeded.
- 15 2. Method as claimed in patent claim 1,  
c h a r a c t e r i z e d in that maximum of the sum of  
the to each user weighted resources indicates the  
allocation of resources between the users.
- 20 3. Method as claimed in patent claim 1 or 2,  
c h a r a c t e r i z e d in that the optimization  
problem is solved provided that the allocated resource,  
at each level, for each user, at least corresponds to  
one for the user lowest resource, and that the allocated  
25 resource does not exceed the total resource of the  
system, and that each user is allocated maximally one  
code.
- 30 4. Method as claimed in any of the previous patent claims,  
c h a r a c t e r i z e d in that the weighting is  
indicated by integers, at which the optimization problem  
is solved by means of, for instance, Branch and Bound  
methods.
- 35 5. Method as claimed in any of the previous patent claims,

c h a r a c t e r i z e d in that the resources are allocated and reallocated between the users depending on the solution of the optimization problem, that the allocation aims at creating free resources which  
5 constitute reserves for changed needs of resources at the users, or for allocation of resources to future users.

6. Device at telecommunication system, utilizing Code  
10 Division Multiple Access, CDMA, technology for exchange of information, for allocation of resources to the users, c h a r a c t e r i z e d in, that the system is arranged to allocate to the users resources corresponding to at least a, by the users requested,  
15 lowest capacity, that the system is arranged to allocate to the users an order of priority, weighting, depending on the order of precedence between the users, that a calculation and allocation unit is arranged to at each moment calculate an optimal allocation of the resources,  
20 and that, based on the calculated allocation, the users are allocated and/or reallocated resources within the capacity of the system.

7. Device as claimed in patent claim 6,  
25 c h a r a c t e r i z e d in that the calculation and allocation device is arranged to calculate maximum for the sum of to the users allocated resources in relation to the given weights, at which the solution of said optimization problem is arranged to indicate the  
30 allocation of the resources between the users.

8. Device as claimed in patent claim 6 or 7,  
c h a r a c t e r i z e d in that, on basis of  
information given by the system, the calculation and  
35 allocation device is arranged to find out the smallest respective largest resource each user needs, and that

the optimization problem is arranged to be solved on condition that the users are allocated at least the lowest necessary resource, and that the total resources of the system are not exceeded.

5

9. Device as claimed in patent claim 6, 7 or 8, characterized in that each user is allocated maximally one code.

10

10. Device as claimed in patent claim 9, characterized in that the code defines the resource that is allocated to the user.

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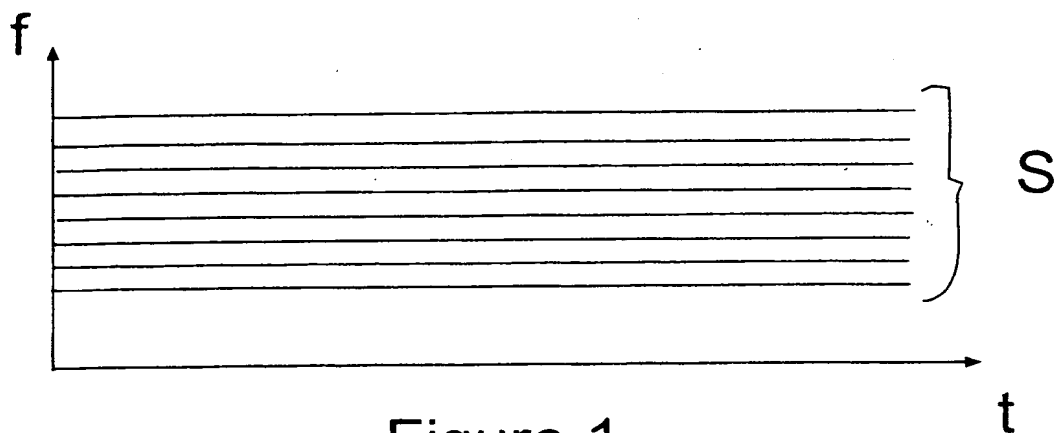


Figure 1

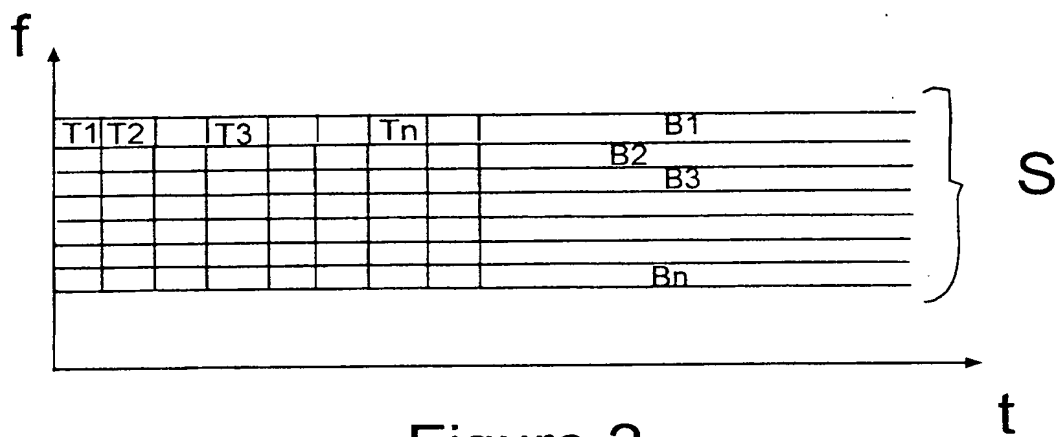


Figure 2

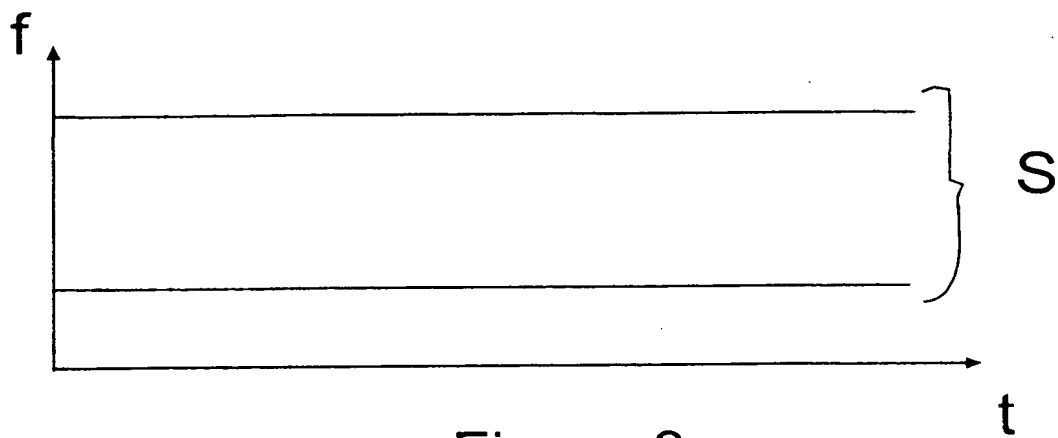


Figure 3

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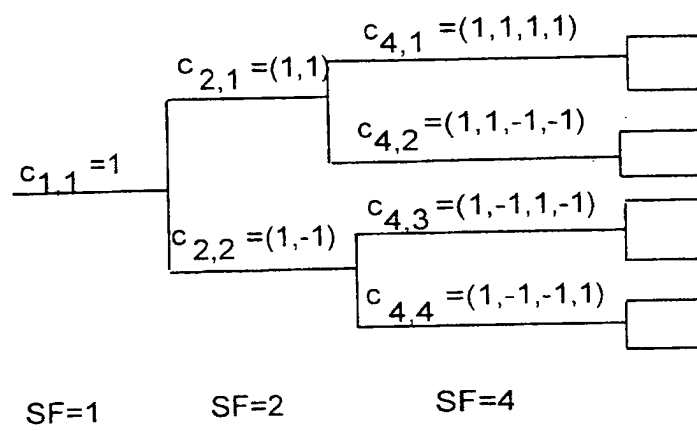


Figure 4



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00674

A. CLASSIFICATION OF SUBJECT MATTER		
IPC7: H04Q 7/38, H04B 1/69 According to International Patent Classification (IPC) or to both national classification and IPC:		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC7: H04B, H04Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5914950 A (E.G. TIEDEMANN, JR. ET AL.), 22 June 1999 (22.06.99), column 4, line 39 - column 5, line 27; column 6, line 16 - column 8, line 65; column 11, line 31 - column 12, line 22, column 22, line 52 - column 23, line 12	1-3,5,6,8,9
Y	--	4,7,10
X	GB 2310972 A (MOTOROLA LIMITED), 10 Sept 1997 (10.09.97), page 5, line 17 - page 9, line 37	1,5,6,8
Y	--	7,10
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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## INTERNATIONAL SEARCH REPORT

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5752194 A (J-H LIN ET AL.), 12 May 1998 (12.05.98), see the whole document --	4
A	DE 19835643 A1 (SIEMENS AG), 10 February 2000 (10.02.00), column 4, line 6 - column 7, line 2 --	1-10
A	WO 9952307 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 14 October 1999 (14.10.99), see the whole document -- -----	1-10

# INTERNATIONAL SEARCH REPORT

Information on patent family members

02/07/01

International application No.

PCT/SE 01/00674

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	5914950	A	22/06/99	AU	7246698 A	30/10/98
				CN	1263675 T	16/08/00
				EP	0974237 A	26/01/00
				TW	391099 B	00/00/00
				US	5923650 A	13/07/99
				WO	9845966 A	15/10/98
				ZA	9802973 A	13/10/98
GB	2310972	A	10/09/97	CN	1181852 A	13/05/98
				EP	0824805 A	25/02/98
				GB	9604822 D	00/00/00
				JP	11504788 T	27/04/99
				US	6122291 A	19/09/00
				WO	9733393 A	12/09/97
US	5752194	A	12/05/98	NONE		
DE	19835643	A1	10/02/00	EP	1103109 A	30/05/01
				WO	0008789 A	17/02/00
WO	9952307	A1	14/10/99	AU	3857199 A	25/10/99
				EP	1066729 A	10/01/01
				US	5923592 A	13/07/99
				US	6122211 A	19/09/00

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